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SOME PROBLEMS OF THE STATE WATER LABORATORY

BY L. H. VAN BUSKIRK

Both the physical and chemical examination of water has been made for many years. The importance of industrial water analysis as related to the commercial use of water in the industries, as well as in the home, developed both chemical and physical methods very early. The sanitary analysis must not be considered as a recent development, for even in the time of Hippocrates, and perhaps earlier, the idea was advanced that waters carrying excessive amounts of organic matter had a decidedly ill effect upon the health of the consumer, and examinations to determine the presence of such material were made. The early development was largely chemical and an attempt was made to devise tests which would show the presence of objectionable substances. With the advancement of the science of bacteriology, the bacterial examination of water was started and has proven of untold benefit to the human family. One by one various determinations and methods have been developed and, as time has progressed, many have been relegated to the field of the worthless.

Various investigators working upon methods of water analysis devised numerous schemes for ascertaining the presence of pollution. With this unorganized work it was realized that much of value was being lost, due to the fact that standard methods for both the chemical and bacteriological examination of water were wanting. The first work of importance which was done in this country, tending to a standardization of methods, was by a committee of The American Association for the Advancement of Science. Their report was published in the *Journal of Analytical Chemistry* in 1887. Since that time the American Public Health Association has followed the work done by this committee, and you are all familiar with the standard methods of both chemical and bacteriological water analysis as prepared and published by the American Public Health Association.

This standardization of methods has been indeed a great step forward in making the analytical results of value, not alone in the con-

trol of impending epidemics from the pollution of private water supplies, but also in connection with the operation of water purification plants. The results are now made of comparative value.

The standard methods of water analysis and the reports of various committees not only emphasize the importance of uniform methods of analysis, but also urge extreme care in the collection of the sample. Much difficulty is encountered, due to the improper collection and transportation of samples to the public health laboratory. The importance of immediate examination of samples has been emphasized, and in many laboratories an attempt is made to secure results in the field by having the regular inspectors or engineers carry field outfits with them, or if the proposition is one which includes a large amount of analytical work, it is possible to ship supplies direct to the point at which the samples are to be collected, and the inspector or engineer is thereby enabled to complete the analyses without delay. The value of this sort of work cannot be overestimated. In some instances, however, especially with private supplies, various public health laboratories are not provided with a sufficient number of inspectors or engineers and it is therefore necessary, if the analyses are made at all, to have the health officer or some other public official collect the specimens and submit them to the laboratory. This procedure is very unsatisfactory. Many times the person entrusted with the collection of the sample does not realize the care necessary to prevent accidental contamination. It is greatly to be desired and urged that all samples of water be collected by regular inspectors, experienced in the work in order to insure that the sample is not accidentally contaminated. Under these conditions much more efficient work can be done.

Of course this does not eliminate the time interval necessitated by the shipment of samples to a central laboratory. It does raise, however, another important point and one which is receiving a great deal of attention at the present time, and that is the character of the shipping container used in forwarding bacterial specimens. In Ohio and several other states, small sample bottles are placed in metal cans which in turn are packed in ice in a zinc lined wooden box. The box is provided with a lid and locked. This sort of container with which most are familiar has not proven entirely satisfactory and several state departments have carried on experiments with various sorts of shipping containers and have found that the thermos bottle, or vacuum bottle is satisfactory. Others have used

the idea of the fireless cooker. In the laboratory of the Ohio State Department of Health we have had little trouble with the older type of container which is still maintained in use.

The value of the sanitary analysis of water as done in the routine of the public health laboratory is in many instances very questionable. The samples are received with the information cards many times only partly or not at all filled out. The analytical work is completed and someone is called upon to make a statement regarding the water. Many laymen have the idea that the determinations made are positive and that the chemist and bacteriologist can determine absolutely as to the sanitary quality of the water. Men who have written concerning the analysis of water have stated many times that such is not the case, and that the analysis of water is but a series of tests which tend to indicate the quality of the water. Now when a water is excessively bad, the analytical results are sufficient to condemn the same, or when unquestionably good, the analysis will so indicate. There is, however, a very broad middle field into which a large majority of the waters fall in their analysis. In this field it is extremely difficult to state without knowing the surroundings as to whether the water should be used or should not be used for domestic purposes. Dr. James Ritchie, in an article on the "Present Relationship of Bacteriology to Water-Borne Disease," in the *Journal of State Medicine*, volume 23, page 211, has covered this phase of the subject very nicely and insists that no samples should be run and no interpretations made of analytical results excepting by the person who collected the sample and inspected the surroundings. Only under such condition can the best results be obtained; otherwise the analytical work is of but little value.

Providing we have proper inspection and the collection of the samples by competent men, then the prime object of the examination is to ascertain whether a water is or is not contaminated by excremental organisms. It follows, therefore, that whatever information is derived from the counts of the total number of bacteria present in the water, that information is altogether subsidiary to the facts obtained as to the presence of organisms of intestinal origin. Judgment regarding a water must necessarily turn on a test for *B. coli*. It must be realized, however, that this is an indirect test and that there are many difficulties and defects encountered therewith. It merely points to a possibility that pathogenic organisms may

gain access to the water. The fundamental defect of the method lies in the impossibility of differentiating between the *Bacillus coli* as it occurs in the intestine of man on the one hand and of animals on the other. Various methods for the presumptive testing of waters for *B. coli* have been suggested and recommended. For a long time lactose bile was used quite generally, but as it was realized that lactose bile under certain concentration had an inhibitory effect on the development of *B. coli*, much work has been done to substitute for this some other medium which would secure a larger number with positive gas formation. Recently lactose broth has come into quite general use and is being used in the laboratory of the Ohio State Department of Health. The attitude which is taken on this subject in the Ohio State Department of Health Laboratory is this: *B. coli*, under certain conditions will cause gas formation in lactose bile, in other cases in lactose broth. In either of these media the production of gas indicates the presence of intestinal organisms. This being the case, why is it not a good idea to use both media, and, should positive gas formation be secured in either, the reports should be positive for *B. coli* as far as gas formation is concerned? This system simply asks a very little additional work and at the same time secures a larger number of positive results than would be obtained with but one of the media used, for it has been observed that in many instances gas is present in lactose bile and not in broth, and vice versa. There is more uniformity in the so-called confirmative tests.

The importance of the chemical determinations of the sanitary water analysis is questionable and many laboratories are reducing the number of these determinations, owing to the fact that they consider the bacteriological findings sufficient for proper classification of the water under consideration. In Ohio those samples collected by the departmental engineers are given a complete bacteriological and sanitary chemical examination; those collected by health officers are not so completely analyzed. Until recently, both chemical and bacterial containers were furnished health officers and others not directly connected with the State Department of Health. The same analytical work was done upon these samples as upon those submitted by the regular engineers. Now, however, only bacterial containers are furnished such people. After the bacteriological work has been started, the sample is transferred to the chemical laboratory and there the physical properties and

nitrites, nitrates and chlorine determined. It is believed that sufficient information can be secured from these results and that additional time and expense to the laboratory is unnecessary. This idea has been developed, owing to the fact that it is realized that the bacteriologist and chemist can furnish only a portion of the data on which a judgment regarding a water can be based. Additional information may be secured by an inspection of the local surroundings which play a very important part in the interpretation of any water analysis.

Certain organizations have set standards for drinking waters. The United States Public Health Service standards for drinking waters for common carriers are familiar to all. These standards are more or less confusing and cause considerable trouble in the public health laboratory. For instance, in our own case all samples collected by the engineers are analyzed and the results returned to them for interpretations, as they only are familiar with the surroundings of the source. In our regular routine work on health officers' samples we make the chemical determinations as outlined above and in addition, inoculate both with 1 and 10 cc. portions of the lactose bile and lactose broth. The ordinary confirmatory tests are also run. Our interpretation of the results is based therefore, upon these determinations. The standards as set by the United States Public Health Service are quite different from this, requiring a different method of analysis. Regardless of our knowledge of the local situation and of the character of the supply, we can only interpret the results in accordance with the standards set. Many peculiar circumstances occur and many times embarrassing situations are encountered. The questions which arise, however, from the establishment of standards of purity for drinking waters are interesting. It is questionable of course, as to the advisability of establishing arbitrary standards. It would seem that the question can best be solved by competent inspection and the regular routine sanitary water analysis, as covered by standard methods of water analysis. When we are enabled to have the coöperation of engineers and laboratory men in this class of work, greater advances can be made in the regulation and control of not only public but private water supplies. This is amply demonstrated by the very valuable work which is being done by the chemists and bacteriologists in charge of water purification plants. Not until we have the inspection of sources and collection of samples by regularly em-

ployed men, trained in chemistry and bacteriology, can we hope to secure the greatest efficiency in the public water laboratory.

DISCUSSION

MR. FRANK E. HALE: One point has been brought up in several papers recently, that is, the question of the necessity for certain determinations in water analysis. The speaker wants to go on record as strongly favoring as complete an analysis upon every sample of water as can be made; not meaning each individual sample, but each source of supply. Some laboratories have merely to pass upon the sanitary quality of the supply. In New York City we have additional problems. For example, waters from supposed leaks are sent in. We have to determine whether they are from the city supply or from sewage, or from ground water. The complete analysis is a history of the water, and should be as complete as possible.

There has been mentioned the question of hardness. Usually that is significant in connection with industrial problems, such as boiler waters, dye works, breweries, etc., but it also occasionally has a sanitary significance. For instance one well supply in the borough of Brooklyn has greatly increased in hardness in the last few years, and the probable explanation is the leakage from cesspools into the ground water. In such cases hardness naturally has a sanitary significance. Iron may not have a sanitary significance, but it does have a bearing upon domestic use and use for laundries.

We get around the question of unnecessary work by making a complete analysis four times a year from every source, and sometimes weekly or monthly, depending upon the water examined. A partial analysis is made monthly or weekly, whenever necessary, of those elements that are most important in that particular source. That practice has been in vogue ever since the Mt. Prospect laboratory was established in 1897. It seems that that is the way to get around the question of unnecessary work. Make a complete analysis a certain number of times a year, and cut down the frequent analyses to what is most important and necessary.

MR. JOHN W. ALVORD: Mr. Van Buskirk's paper and his remarks have been centered upon a very important subject; one which in the past has not been honestly enough discussed.

The chemical profession, the sanitary engineering profession, and, in fact, all professions suffer more or less from the misconception that they are exact. Engineers, for instance, are believed to be marvels at mathematical processes, and, therefore, everything they do is looked upon as precise and final. Chemists and bacteriologists come under the same category. A large portion of the public holds this popular misconception. As a matter of fact, it is an entirely erroneous view of our proper functions. We are not exact and we are not precise in the sense that the public imagines. We are a judicial profession. Our real function is to sum up the evidence, array the facts, brief each stage of the case, look over the conditions submitted with proper discrimination and draw general conclusions. The sanitary engineering and chemical profession is a judicial profession much more than it is a precise, exact, or mathematical profession; and the chemical or bacteriological work of the engineer and chemist is primarily the art of using mature judgment and competent opinion on an array of evidence that is often incomplete. It seems to the speaker that we have not only to recognize this fact among ourselves, but that we must be entirely frank with the public about it, much more frank than we have been.

The public shows an improper confidence in us by sending us samples of water from some unknown source, with unknown conditions, and asking us if it is good or bad. That is a common experience of the state laboratory and of all laboratories. What ought we to do under such circumstances? The speaker would say that the frank and the entirely proper thing to do is to mark on the sample, "Insufficient evidence submitted", along with any other determination which might be properly made in the line of duty. The absence of frankness of this kind is responsible for a great deal of the embarrassment that the laboratories are subject to, such as has been discussed by Mr. Van Buskirk, and, until we come to have this kind of frankness with the public, we shall not create in it an understanding of what really are our judicial functions as analysts and as sanitarians. We cannot be led blindfolded into a field, allowed to pick one flower, and then, carrying it into the laboratory, be made to tell what kind of hay is going to be harvested, or what kind of botanical products are derivable from the field. Let us be honest and frank and say so. Let us stop misconceptions on the part of the public. It is folly to allow the public to mislead itself, and yet we will all find at times samples of waters sent, with in-

sufficient data from which a fair determination cannot be made, and an opinion is returned in exceedingly cautious language, it is true, but without the frank admission, which should be written on every such sample, in these words, "Insufficient evidence submitted for final opinion".

MR. F. W. MOHLMAN: The speaker was especially interested in Mr. Van Buskirk's remarks about educating the laity to comprehend what water analysis means, and also his remarks concerning inspections. At the Illinois State Water Survey probably 75 per cent of the samples are from wells in small towns, and of that 75 per cent we usually find that 10 per cent are not collected according to instructions. Physicians are the worst offenders. Instructions are put into every sample container, so that there is no reason for them to make a mistake in collecting samples. It seems that the physicians are as much to blame as the water analysts in neglecting their duty toward the public, in not explaining what the analysis means, and also in not following directions in the collection of the samples. We had an instance of what this means in Illinois a short time ago, in connection with a typhoid fever epidemic. The sample containers were sent to a physician, the president of the local board of health, who collected the samples and sent them in. The usual analysis comprises both a sanitary and a bacteriological analysis. Specific instructions were given in this instance. This physician sent in three samples from three wells for bacteriological analysis, and three samples from three other wells for sanitary and chemical analysis. The practice in ordinary cases would be to refuse to give an opinion on any of these waters. It was necessary to postpone the report until we could get the waters properly collected. This delay was wholly due to the carelessness of the town physicians. We have found them to be the worst offenders.

MR. CHARLES P. HOOVER: The speaker had rather a funny experience at Columbus recently. The water department analyzed about 2000 private wells and about 35 per cent of them were pronounced bad. One day a physician requested a sterilized bottle, stating that he would like to have the water from his well examined. He received the bottle, and the following day sent the sample to the laboratory for analysis. For some unknown reason it was felt that

there was something wrong about the fellow, and that he was trying to put something over on the laboratory. A very simple chemical test was made of the water which he submitted, and it showed that the water was not well water but the city filtered product. Lime and soda ash are used to soften the water supply of Columbus, and consequently the water has an alkaline reaction, and gives a red color with phenolphthalein, so that it is very easy to identify it. As soon as it was found that it was city water, and not well water as represented, no trouble was taken to make a bacterial analysis, but a letter was written to the wise gentleman saying that his sample of water had been received, and that the analysis showed it to be the best sample of water that had ever been submitted to our laboratory for analysis.

MR. ARTHUR R. TAYLOR: The speaker was very much interested in Mr. Van Buskirk's paper, and some of the things he relates as to the analysis of water, and its relation to water supply problems, recall an incident which occurred recently before the Public Service Commission of one of our largest states on a question of the purity of a certain water supply. One of the members of the commission was evidently bent on studying water analysis. On being told that we could not distinguish between intestinal organism, whether from human or animal source, he seemed to think that if such were the case he could not see what use there was in water analysis.

HON. JAMES J. POWIS:¹ The speaker has been very much interested in the paper of Mr. Van Buskirk, and especially in the statement that the railroads of the United States were beginning to see the necessity of sanitation, and to secure proper conditions, and were commencing to show an interest in the problem of securing pure water supplies. This is especially interesting for this reason: for many years, according to the statistics, the railroad reports of the United States, the railroads of this country have transported some 800,000,000 people per year, and the methods of the disposing of the human excreta from these trains is upon the railroad tracks and the highways, often over sections of the country where the water-sheds or natural drainage, wash this excreta into the streams.

¹ State Senator of New York State.

It would be a grand thing if a consensus of opinion of this distinguished body would be to encourage the railroads to cease this mighty pollution which they can very easily do. The inventive minds of the country will very quickly provide them with means if they show any desire to adopt them. That the railroads, boats, and highways of this country should furnish pollution continuously, and that the streams and rains should carry it into the waters of every state wherein they run, seems monstrous in this age.

THE CHAIRMAN: That is a point that is well taken. Most of us are familiar with what is being done in the west for the alleviation of such sources of contamination of water supply. There are state boards of health and a national board of health in this country and in Canada who are looking after matters of that kind.

MR. CHESTER G. WIGLEY: The presentation of facts by Mr. Van Buskirk is very interesting to anyone connected with a state board of health. It is a common thing to find that the ordinary man sends a sample of water to the laboratory, and looks upon the determination made from examination of the water as something akin to the black art, thinking that a man can take a sample of water, often times submitted in a pill bottle, and, by some peculiar process of examination, tell where it came from, and what came with it, and everything else. But the water works man has gotten beyond that point, at least in New Jersey. The container that is supplied by the State Department of Health is very carefully prepared, sterilized, and sent out with certain slips supplying certain information, exact information, as to how to obtain the sample for examination. If a sample of water is sent in an ordinary preserving jar, the general attitude of the State Department of Health is to reply to the man that the sample is unsatisfactory for analysis, and to proceed to deposit it in the sink. The matter is then taken under consideration, and if it appears that there is any necessity for the collection of a sample, a man is sent to check up the conditions. It is a rather difficult proposition to educate the people along these lines, because the public water works official is not as permanent in his tenure of office as he should be in a great many ways. By the time one man is educated a new man is put upon the job. It has been found that probably the most valuable data are obtained not so much by the chemical analyses that are made

in the laboratory as by the actual inspection of the water supplies in the state. Some of these inspections have been startling in a way, as showing potential possibilities of pollution; for instance, there was recently found one water supply that, as far as known, was obtained from very deep wells; upon investigation it was found that there was a connection with a brook that was very badly polluted. Fortunately this had not been used, but had it been used the possibility of an epidemic from typhoid would have been a very serious matter. This leads to a consideration of the standards that are required for a water that is used upon a public carrier. The experience in some cases has been in a way contrary to the ordinary experience; in some instances analyses have shown that the water supply would be entirely satisfactory, and upon examination of the water supply it was found that it was constructed and maintained in such a way as to be, by our standards, a very dangerous supply to draw water from. This relates more particularly to the small water supplies used by railroads at small stations where there is not a public water supply. The standards of the federal government are but little more than a yard stick or measuring device which is applied to any given water supply a certain number of times, and in that way a measure is obtained of the quality of the water. In the speaker's mind there has been slowly forming the thought that a better and more satisfactory way of measuring the water supply, and the quality of the water supply, is to depend not so much upon the chemical and sanitary analyses of the water as upon the basis of a system somewhat similar to that used in scoring dairies, which would be a summation of the conditions and factors that are of importance in the maintenance of a proper water supply.